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Foundations First

Foundational computer science at the heart of biodiversity science

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PART I

Where we've come from

Every computing revolution reshaped how science is done.

Every computing revolution reshaped how we study life

Mainframes, the internet, now AI — each wave changed what a biodiversity researcher could ask, and how they worked.



The tools kept changing

And researchers had to adapt to each new wave.



The lasting ones saw it coming

They built for where computing was heading — not just today's tool.

AI is the next wave, and the biggest yet — and with biodiversity in crisis, the science must matter at the scale and speed the world needs. Where is AI taking it?

Electricity: from novelty to sovereign infrastructure



It became the utility

A curiosity turned into the invisible thing everything runs on.



Access decided who led

Nations that electrified surged ahead; those without fell behind.



Control became strategy

Who owns the grid owns the power. Energy sovereignty is national policy.

Computing — and now AI — is the same story: a general-purpose power we come to depend on.

Computing and biodiversity research, decade by decade



Each wave gave new power — and demanded new foundations, guardrails and skills.

When running a model meant a deck of punch cards



Punch the cards

One mispunched hole broke the whole run.



Wait for the operator

You queued at the centre; results came back in days or weeks.



Fix it by hand

Debugging was physical — re-punch a card, tape over a hole.

Compute was scarce and mediated — the researcher never touched the machine.

How the web changed the researcher's day



Before the web

- Card catalogues, print indexes, inter-library loans
- Weeks to find what already existed



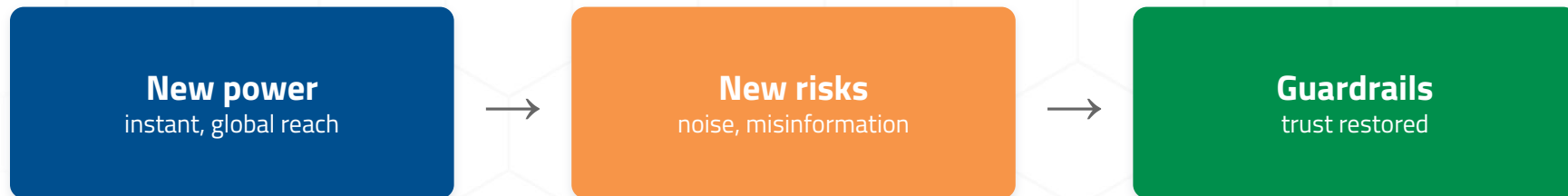
After the web

- Digital libraries, Google Scholar (2004)
- Full text and citations in seconds

WWW: Berners-Lee (1989/1991). It also brought overload, spam and predatory journals.

New power, new risks — then guardrails

Every leap became trustworthy only once we built the guardrails that earned trust.



The web → peer review online, DOIs, indexing. AI now needs its own.

AND ONE THING NEVER CHANGED • PEOPLE IN BETWEEN

Every era needed a human intermediary



The operator

Ran your punch-card model; you waited days.



The librarian

Fetches the paper you needed — one request at a time.



The software engineer

RSEs wrote and operationalised your code — project by project, right up to today.

This was the era just before AI — co-design slow and one-by-one. AI is about to change that, at scale.

PART II

Where we are now

AI: the opportunity — and the break in trust.

AI does what no researcher could do alone



Sees what we can't

Identifies species from millions of images and sounds; links occurrence, genetic and trait data no one could read in full.



Codes in seconds

Complex code instantly — with every software-engineering method applied.



But volume isn't validity

A large, well-engineered codebase can still be immature — and scientifically empty.

Species identification, e.g. BirdNET (Kahl et al., 2021). Code generation: Chen et al. (2021), Codex.

A convincing paper no longer means a sound one

Peer review assumed a paper was the honest work of a trusted researcher. AI dissolves that assumption.



Authorship ≠ trust

A “paper from a trusted researcher” can now be machine-made in minutes.



Review can't keep up

End-stage peer review was never built for this volume — or this kind of error.

You can't stop AI — so own it, safely

No one stopped electricity or the computer. AI is no different — the question is not whether, but who controls it and whether it is safe.



Inevitable

It will be used everywhere — resisting it is not an option.



Sovereign

We cannot let a foreign layer own AI for European science.



Safe & compliant

The best of AI — trustworthy, and aligned with the EU AI Act.

A research infrastructure can guarantee all three. Its role here is not empty — it is essential.

Overestimated now, underestimated later

As with every general-purpose technology, we overestimate AI in the short run and underestimate it in the long run (Amara's Law) — expect a correction before the payoff.



AI is already used everywhere, for good reason — it just hasn't reached biodiversity researchers yet. The way through: explore together, understand their needs, and train them.

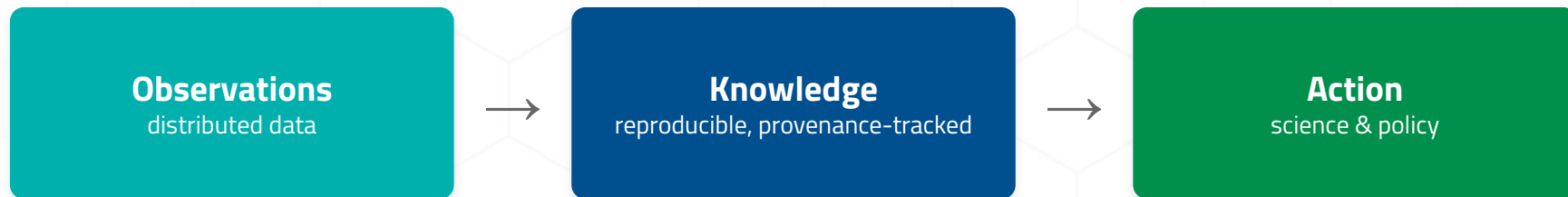
PART III

Where we're heading

A research infrastructure that makes AI trustworthy.

What we're building toward: Biodiversity Intelligence

Biodiversity Intelligence: turning distributed observations of the living world into robust, reproducible, actionable knowledge.



The value is not the data — it is the trusted transformation.

This is what a research infrastructure is for

No single lab can build trusted data, guardrails, verification and sovereign compute. A research infrastructure — funded by its member states — builds them once, for the whole community.



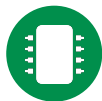
Trusted data

Authoritative, FAIR ground truth to check against.



Embedded verification

Guardrails wired into every workflow.



Sovereign compute

European AI power, via national AI Factories.



Co-design at scale

Expert support with every researcher, always on.

Built by the countries that invest in it — and the more you take part, the more it delivers.

Work with data you could never master alone



Across disciplines

Use genomics, climate and remote-sensing outputs you'll never be an expert in — the infrastructure bridges them into ecosystem Digital Twins you can model and query.



Data that describes itself

As FAIR Digital Objects (FDOs), your datasets, software, workflows and papers carry their meaning and limits — so they combine and crosswalk to new fields automatically.



From the field, faster

Field observations flow to analysis and insight on site — not months later.

The daily work changes: less wrangling, more discovery — across boundaries no one could cross alone.

CONCRETELY • THROUGH THE RESEARCH LIFE CYCLE

An AI agent alongside you — at every step

Like a LifeWatch expert who never leaves your side — with you at every stage, anytime.

1

Plan

Finds the data, tools and prior work you need

2

Collect

Structures your data to standards as you go

3

Analyse

Runs workflows & ecosystem Digital Twins; checks results

4

Share

Prepares FAIR, reviewed, citable outputs

5

Preserve

Keeps everything traceable and reusable

The support that was scarce and one-by-one — now with every researcher, always on.

Verification, built into workflows, tools and papers



Workflows

Reproducible and provenance-tracked; wrong species names caught against authoritative registries.



Tools

Outputs checked against data and assumptions before they are trusted.



Papers

Every result links to the workflow that made it — verification embedded, not bolted on at review.

The claim in the paper traces back to the checked workflow behind it.

Linking species records to satellite habitat data



Without the infrastructure

- Which standards apply? (Darwin Core, STAC, CF...) — no one can know them all, least of all across climate, biodiversity and socio-economic data
- How do you align datasets on a common spatio-temporal grid? Which grid — and what uncertainties does that introduce?
- Limited to existing data cubes — regridding is hard, so integrating new datasets is challenging



With the AI agent + guardrails

- The agent knows and applies the right standards — across domains you'll never master
- It aligns data on a fitting grid, and makes the resulting uncertainties explicit
- It regrids on demand and builds new cubes — integrate new data freely

Guardrails aren't limits — they are the expertise that makes combining data correct, and new questions possible.

The evidence layer that trustworthy AI needs

As AI enters science and policy — and the EU AI Act demands it be tested — someone must be the trusted place to do so.



Tools & standards = the assay

Trusted tools, standards and software to test against — the guardrails apply them, so researchers needn't.



VREs = the sandbox

Controlled, reproducible, supervised testing.



Experts = the judgment

Ecologically correct — not merely plausible.



Monitoring = pharmacovigilance

Watching deployed models drift over time.

The regulator is the tip; the research infrastructure is the iceberg — we equip whoever rules.

Operationalise the known — and explore the new

AI makes operationalisation easier — so it can't be our only edge. The advantage now is at the frontier.



Operationalise

Turn methods into stable services — necessary, now easier with AI.



Explore the frontier

Invest in exploration, not only consolidation — that is the edge.



Collaborate

Partner with those pushing frontier science, AI and computing.

What we owe our member states and researchers: operationalise the known — and explore the new.

New roles for new foundations

As in every past technology shift, some roles fade and new ones appear — the opportunity grows.



Less: boilerplate coding

AI writes the routine code; the pure software-engineering role shrinks.



More: Forward Deployment Engineers

Experts embedded with researchers in the field — turning needs into trusted tools, and judging what the AI built.



More: literate researchers

Who question fluent-but-wrong output, use the guardrails, and keep asking new questions.

The research software engineer of yesterday becomes the forward-deployed engineer of tomorrow.

This is where LifeWatch ERIC is heading

AI is the opportunity of our generation for biodiversity science. LifeWatch ERIC exists to seize it safely — the shared infrastructure, funded by its members, that turns distributed observation into trusted Biodiversity Intelligence. That is the road we are on.



Build the foundations

Self-describing data as FAIR Digital Objects, embedded verification and guardrails, ecosystem Digital Twins, and sovereign compute via national AI Factories.



Grow the people

Forward-deployed engineers, and researchers as literate participants.

References & further reading

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Join us — there's a way in for everyone



Join as a member

Bring your country into LifeWatch ERIC as a member — help shape the roadmap, and give your researchers accredited AI workflows, Digital Twins and sovereign compute no nation builds alone.



Use it & co-design

Already in a member state? Use the infrastructure, co-design tools with our experts, and contribute your data, workflows and expertise to the shared layer.



Start as an observer

Your country is not yet ready to join fully? It can start as an observer — take part in the community and see the value before committing to membership.

The more a country and its researchers take part, the more LifeWatch ERIC gives back.

AI is no magic.

Like electricity. Like the internet. What lasts is the foundations we build — and the people who build them.

Thank you · Anne Fouilloux · LifeWatch ERIC · doi.org/10.5281/zenodo.21215199